



Detailed Forensic Report Certification

I, Paul C Greene, declare:

That I am Manager of Forensic Services at ShotSpotter, Inc. I have personal knowledge of the following matter, and, if called as a witness, could and would testify thereto. I have prepared the report and any attachments, identified below, which is attached hereto.

I declare under penalty of perjury under the laws of the State of California that the report is true and correct.

Report:

City:	Chicago, IL
Zone:	District 920
Reference Date:	4 MAY 2018
Customer's Ref. #:	1812401915
Report Date:	08 APR 2019
MD5 Hash (PDF):	3114C234F81DDF259E2254D1E20FB8BF
SVN Revision (PDF):	73633

Executed this 10 of APR, 2019, at CITRUS HEIGHTS, CA.

Paul C Greene

pgreene@shotspotter.com

Shooting Description

At 03:18:15 (3:18:15 AM) hours on May 04, 2018 ShotSpotter detected a Multiple Gunshot incident in Chicago, IL. ShotSpotter recorded the incident as Flex ID #34128 and located it at 1720 W 44th St.

Position with Respect to the Coverage Area

Figure 1 – ShotSpotter Coverage Area: The image below displays the ShotSpotter coverage in Chicago, IL at the time of the incident. The red dot indicates the location of the shooting incident.

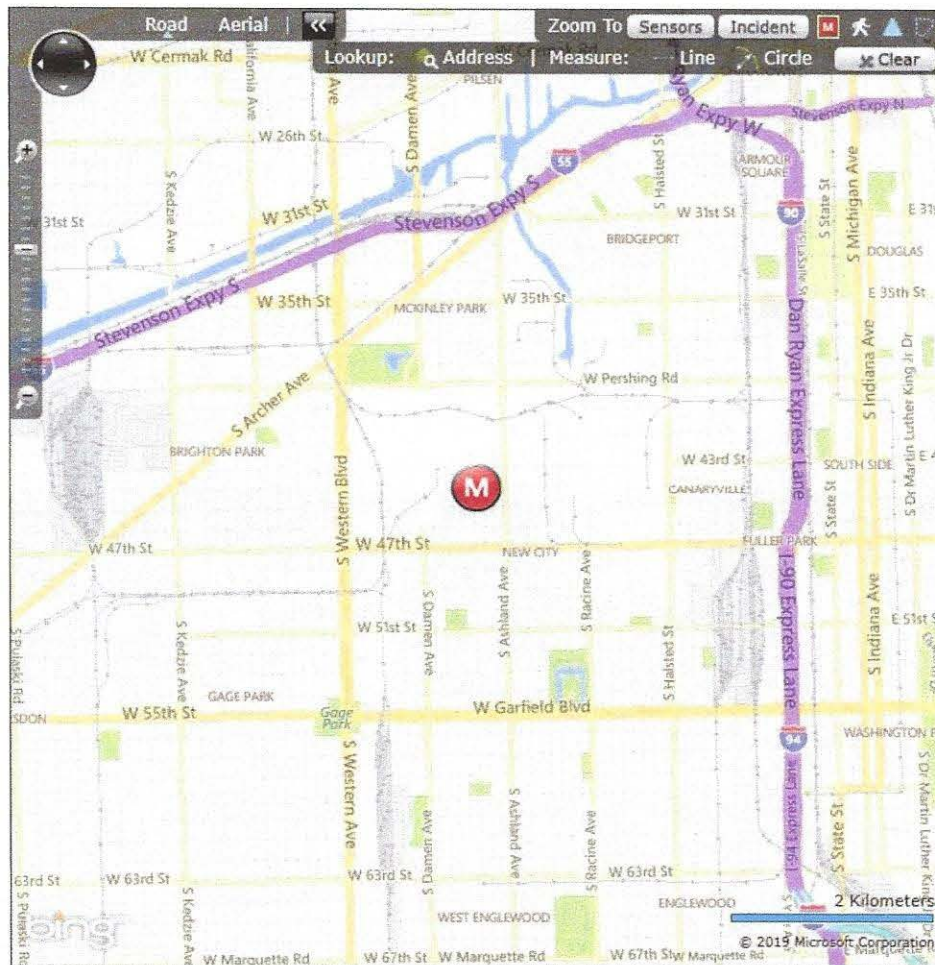


Figure 1 - ShotSpotter Coverage Area Chicago, IL



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Auto-detected by ShotSpotter? Yes

About ShotSpotter

ShotSpotter was installed in Chicago, IL (ChicagoILDistrict920) in 2017. ShotSpotter has three primary components: acoustic sensors, a Location Server application, and a ShotSpotter Flex user interface application. The ShotSpotter Location Server is operated by ShotSpotter, Inc. and runs on a virtual server hosted at a remote facility, the ShotSpotter user interface resides on the customers PC or mobile device. Acoustic sensors are deployed in geographic areas that are designated by the customer.

Each sensor is triggered by impulsive sounds in its environment. The acoustic measurements of these impulsive sounds and the exact time that they were detected are transmitted, by individual participating sensors, to the Location Server as probable gunshots. The Location Server analyzes the data received and determines if the impulsive sound can be geographically located and classified as gunfire. If the impulsive sound can be located and classified as gunfire, Location Server reports the incident to the ShotSpotter Incident Review Center where a human operator reviews the incident for classification accuracy. The reviewed incident is then published to the customer's user interface. The user interface provides an actionable view of the incident with an emphasis on the time and location of the incident. Gunfire incidents are typically detected, located, classified, reviewed, and published to the customer within 60 seconds of the weapon being fired.

The discharge of a firearm creates a loud, impulsive sound that, under optimum environmental conditions, can be detected above urban background noise up to two miles away from the firing incident location. Thus, the operation of ShotSpotter is understandably subject to the laws of physics and acoustic propagation.

ShotSpotter detects and properly geo-locates (provides latitude and longitude) 90% of detectable outdoor incidents within the coverage area, accurate to within a circle whose radius is 25 meters (82ft). ShotSpotter, Inc. does not guarantee 100% detection because real world environments may contain intervening buildings, topography, foliage, periods of increased traffic or construction noise, and other urban acoustic noises that may either prevent the sound of a gunshot from being detected by the sensors(s), or may change or modify the audio characteristics of the sound of a gunshot so that it no longer matches the sensor(s) detection parameters.

Other factors, such as obstructed or attenuated muzzle blast, weapon discharge in an enclosed space, or if the weapon discharged is of .25 or smaller caliber, may also prevent the sensor(s) from not detecting all, or some shots fired.

Analysis

Figure 2 – Incident review: At 03:18:15 on May 04, 2018, ShotSpotter detected and located a Multiple Gunshot incident in Chicago, IL. Below is a table which shows the timeline of the incident being updated.

Search Results		M 34128
Source:	ChicagoILDistrict920	
Details:	2 ROUNDS	
Rounds:	2	
District:		
Beat:	0924	
Latitude:	41.813993	
Longitude:	-87.66856	
Address:	1720 W 44th St	
CAD ID:	1812401915	
Date/Time:	5/4/2018 03:18:15	
azuniga@shotspotter.com		May 4 03:18:44
Reclassified : Multiple Gunshots		
azuniga@shotspotter.com		May 4 03:18:47
Changed number of rounds from 1 to 2		
azuniga@shotspotter.com		May 4 03:18:50
Published		
pc0v630@chicagopolice.org		May 4 03:18:55
Acknowledged at customer facility		
pc0v630@chicagopolice.org		May 4 03:30:39
Closed at customer facility		

Figure 2 – Incident review timeline. Flex ID #34128

Figure 3 – Address Location: The image below displays the shooting location as calculated by ShotSpotter. The address of 1720 W 44th St was read from either a database of parcel information provided by the city or county and uploaded into ShotSpotter or is sourced from the satellite map provider. The red dot indicates the location of the shooting incident as calculated by ShotSpotter in real-time and reported to the ShotSpotter operator.

The red circle indicates a 25m accuracy radius for gunshot incidents that occur within the boundaries of the coverage area depicted on page 1 and is present in the image for reference only.

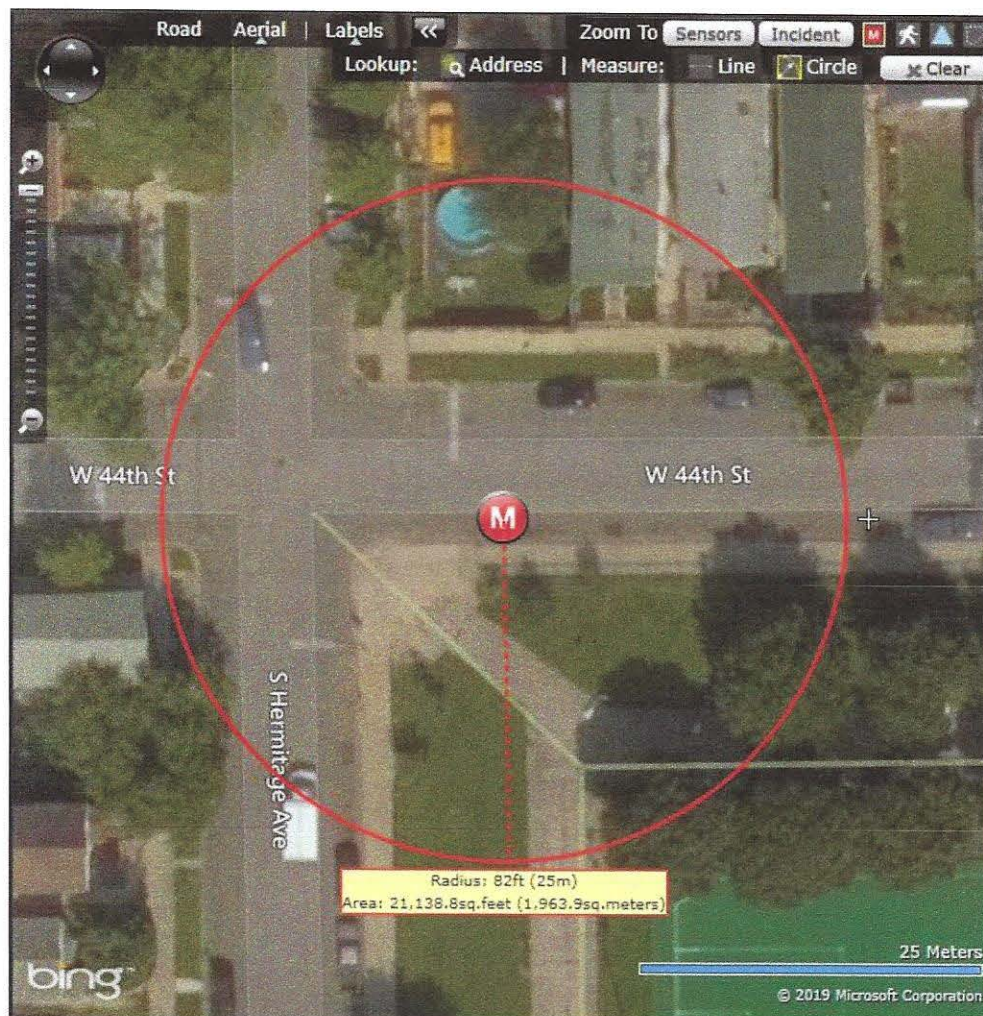


Figure 3 –Address Location, Flex ID #34128

Table 1 – Timeline of Discharge of Shots and Calculated Shot Locations: The following table shows the time of discharge, and the calculated Latitude and Longitude for each of the shots which comprise this shooting event. The times listed below are the time the system calculated the trigger was pulled based on the environmental conditions at the time of the event. These times precede the time at which the system notified the ShotSpotter Operator listed because of small radio, computational, and network delays. All times are obtained from network, system, and sensor clocks that are synchronized to GPS time, which is in turn synchronized with the atomic clock at the National Institute of Standards and Technology in Boulder, CO.

On May 04, 2018, ShotSpotter Customer Support was contacted by the Chicago Police Department who requested a search for audio of additional shots fired either before or after Flex 34128. After a search of sensors in the vicinity of 1720 W 44th St, audio of 5 additional, undetected, shots was located on 4 sensors and downloaded. These audio clips were then used to calculate the times and locations of the 5 additional shots as well as the 2 shots that were automatically detected by ShotSpotter as Flex 34128. All calculated shot times and locations are detailed in the table and images below.

Flex ID#	Shot	Discharge Time	Latitude	Longitude
	1	03:18:10.645	41.814733	-87.668907
	2	03:18:11.137	41.814736	-87.668912
	3	03:18:11.417	41.814731	-87.668900
	4	03:18:11.693	41.814737	-87.668906
	5	03:18:12.952	41.814732	-87.668905
34128	6	03:18:14.833	41.813964	-87.668501
34128	7	03:18:15.148	41.813963	-87.668495

Table 1 – Shot and Location timeline, Flex ID #34128

Figure 4 – Individual Shots Fired: The following image depicts the location of each shot onto a satellite image. The latitude and longitude of each shot is calculated by post-processing an incident's audio clips and archived data. Post-processing is a "manual" re-evaluation of incident data through software tools that duplicate the real-time location algorithms that are a resident part of the ShotSpotter Location Server. Post-processing can be selectively performed on subsets of the raw data so that noises from different sources can be isolated for analysis.

In the image below, the red dots indicate the latitude and longitude location of each of the shots as detailed in *Table 1*.

After analysis, the 5 undetected preceding shots were located at: 4338 Hermitage Ave



Figure 4 – Individual Shot Locations, Flex ID #34128

Multilateration:

The source of an acoustic pulse (a sound that goes bang, boom, or pop) is located using a mathematical process called multilateration. Multilateration requires a minimum of three sensors that surround the source to accurately report the time that a pulse is detected. Each participating sensor will detect the same pulse at slightly different times. The Location Server calculates the time differences of detected pulses between unique pairs of sensors against the speed of sound (343 meters per second, or 768 mph) to generate a curve called a hyperbola. All the resulting hyperbolae are then plotted onto a map. The spot where the hyperbolae intersect is where ShotSpotter locates the shot. When more than three sensors participate in the detection, Location Server performs automatic calculations to find a solution that minimizes the error to the greatest extent possible.

The image below is a pictorial representation of the hyperbolae calculated during the analysis of this shooting event. The map space depicts the shooting location at the intersection of the hyperbolae and the positions of the sensors used in the analysis relative to the shooting location.

Figure 5 – Multilateration plot: 7 ShotSpotter sensors participated in automatically detecting and locating Flex ID #34128. Post-process location analysis was performed using audio clips and saved pulse data from 4 sensors.

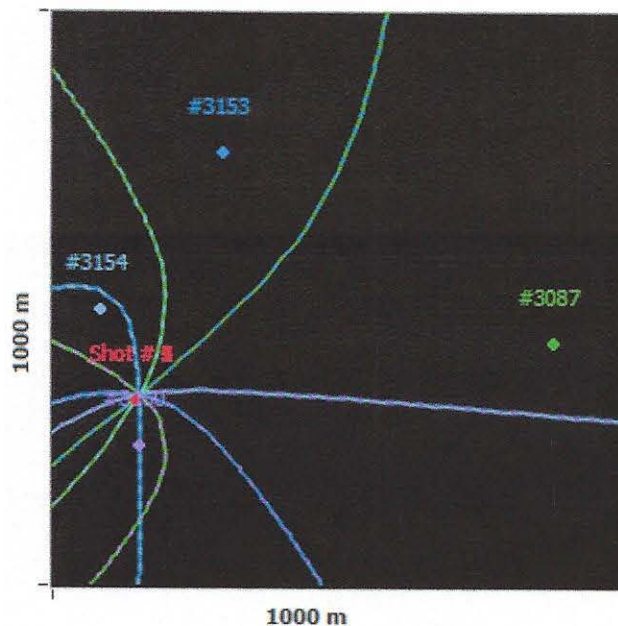
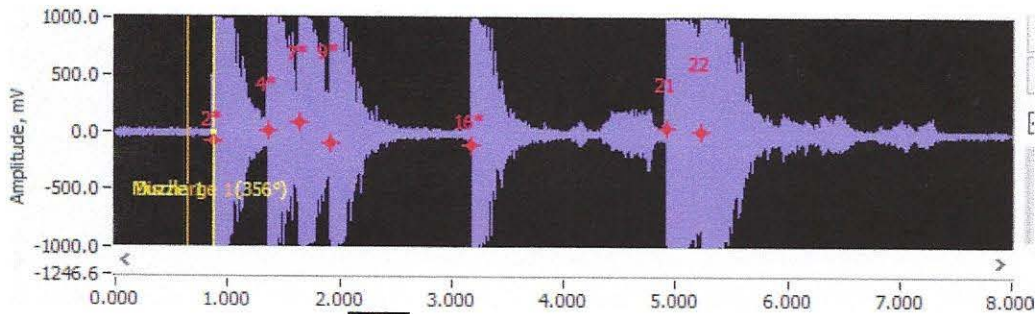


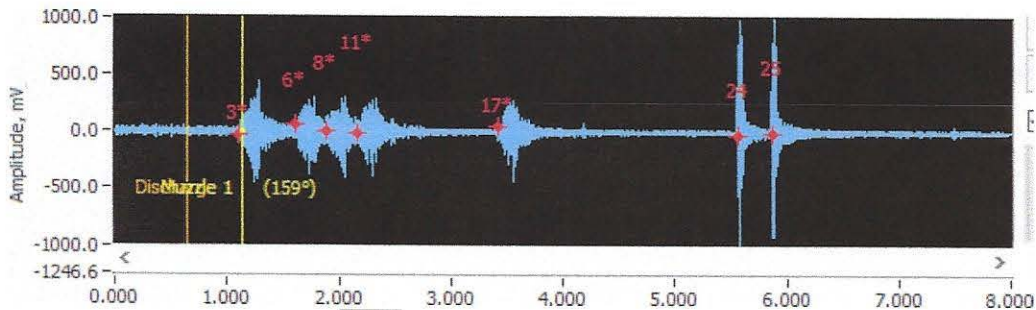
Figure 5 - Multilateration, Flex ID #34128

Site-specific Acoustics

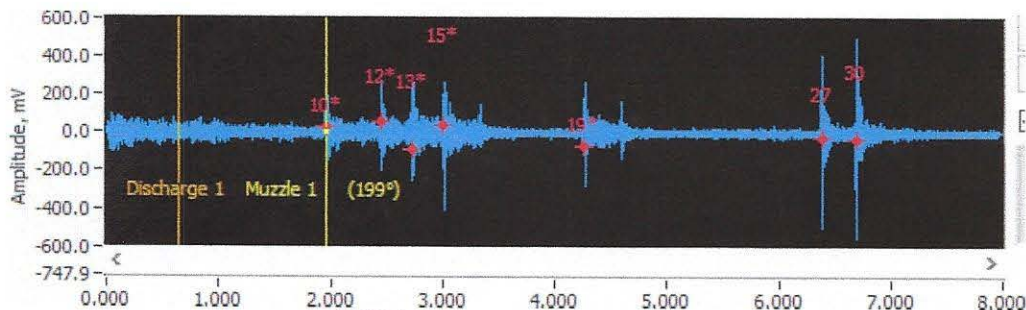
The depicted audio waveforms below, visually represent the incident audio that was recorded by, and downloaded from different sensors. Each sensor number indicates the calculated distance from that sensor to the incident location. (Click the speaker icons to play the audio from each sensor.)



Sensor 3160 (77m)



Sensor 3154 (171m)



Sensor 3153 (462m)



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Conclusion

At 03:18:15 (3:18:15 AM) hours on May 04, 2018 ShotSpotter detected a Multiple Gunshot incident in Chicago, IL. ShotSpotter recorded the incident as Flex ID #34128 and located it at 1720 W 44th St. After analysis, the 5 undetected preceding shots were located at: 4338 Hermitage Ave

After review, the locations and times of 7 rounds fired were calculated.

Acoustical data analysis of a gunfire incident is complex and not comprehensive. The conclusions above should be corroborated with other evidentiary sources such as recovered shell casings, and witness statements.



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Certification and Acknowledgement

Certification

I, Paul C Greene, declare that I am Sr. Forensics Engineer at ShotSpotter Inc. I have personal knowledge of the matter referred to in this report, and, if called as a witness, could and would testify thereto. I declare that the above is true and correct.

Executed this 10 of APR, 20 19,
at CITRUS HEIGHTS, CA.

Paul C Greene

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A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document

California All-Purpose Certificate of

Acknowledgement

State of California)
County of Sacramento

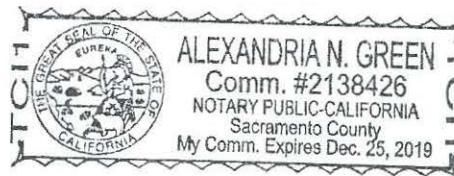
On 10 April 2019

before me Alexandria N. Green
Notary Public personally appeared Paul C Greene who provided to me on the basis of satisfactory evidence to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

I certify UNDER PENALTY OF PERJURY, and under the laws of the State of California, that the foregoing paragraph is true and correct.

Witness my hand and official seal.

Signature Alexandria N. Green
Notary Public



(Seal)